1   TITLE

2   Adaptive Engine Logic Used in Training Academic Proficiency

3

4   CLAIM OF PRIORITY/CROSS REFERENCE OF RELATED

5   APPLICATION(S)

6   This application claims the benefit of priority of United States Provisional

7   Application Number 60/459,773, filed April 2, 2003, entitled "Adaptive Engine

8   Logic Used in Training Academic Proficiency," hereby incorporated in its

9   entirety herein.

10

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18   STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR

19   DEVELOPMENT

20   Not applicable.

21

1

2   BACKGROUND

3   1. Field of the Invention

4   The present invention relates generally to computerized learning and more

5   particularly to an adaptive learning system and method that utilizes a set of

6   heuristics to provide a learning environment unique to an individual.

7

8   2. Description of Related Art

9

10   The Problem

11   A child's learning pace varies from child to child. Schools often provide

12   education that is tailored to a general standard, to the "normal" child. Teachers

13   and facilitators often gear materials, e.g. static curriculum, and pedagogical

14   direction toward the majority of the classroom – the so-called normal child – and

15   therefore neglect children with different needs on either end of the spectrum.

16

17   Because the collection of concepts mastered by different students varies, without

18   a personalized curriculum tailored for the student, it is oftentimes difficult to help

19   different students with different abilities to develop a solid foundation in a

20   particular subject.

21

1   <u>Prior Art Solutions to the Problem</u>

2   There are a number of education-based, and more specifically math-based,

3   Internet web sites available today. Also, there are many offline products, such as

4   workbooks, CD-ROMs, and games that also address this issue. In addition there is

5   also traditional human help, such as a teacher and/or tutor.

6

7   Commercial examples in the math arena:

8

9   www.aleks.com - A fully automated online math tutor for K-12 and Higher

10 Education students. Below is an excerpt from their corporate website.

11

12 ALEKS is a revolutionary Internet technology, developed at the University of

13 California by a team of gifted software engineers and cognitive scientists, with the

14 support of a multi-million dollar grant from the National Science Foundation.

15 ALEKS is fundamentally different from previous educational software. At the

16 heart of ALEKS is an artificial intelligence engine -- an adaptive form of

17 computerized intelligence -- which contains a detailed structural model of the

18 multiplicity of the feasible knowledge states in a particular subject. Taking

19 advantage of state of the art software technology, ALEKS is capable of searching

20 an enormous knowledge structure efficiently, and ascertaining the exact

21 knowledge state of the individual student. Like "Deep Blue," the IBM computer

1   system that defeated international Chess Grand master Garry Kasparov, ALEKS

2   interacts with its environment and adapts its output to complex and changing

3   circumstances. ALEKS is based upon path breaking theoretical work in Cognitive

4   Psychology and Applied Mathematics in a field of study called "Knowledge

5   Space Theory." Work in Knowledge Space Theory was begun in the early 1980's

6   by an internationally renowned Professor of Cognitive Sciences who is the

7   Chairman and founder of ALEKS Corporation.

8   • Using state-of-the-art computerized intelligence and Web-based

9   programming, ALEKS interacts with each individual student, and functions as

10   an experienced one-on-one tutor.

11   • Continuously adapting to the student, ALEKS develops and maintains a

12   precise and comprehensive assessment of your knowledge state.

13   • ALEKS always teaches what the individual is most ready to learn.

14   • For a small fraction of the cost of a human tutor, ALEKS can be used at any

15   time: 24 hours per day; 7 days per week, for an unlimited number of hours.

16

17   Kumon Math Program- a linear and offline paper-based math program that helps

18   children develop mechanical math skills. 2.5 million students or more worldwide.

19

20   Math Blasters- A CD-ROM that provides some math training through fun games.

21

1   Ms. Lindquist: The Tutor – a web-based math tutor specialized in helping

2   children solving algebraic problems using a set of artificial intelligence

3   algorithms. It was developed by a researcher at Carnegie Mellon University

4

5   Cognitive Tutor – Developed by another researcher at Carnegie Mellon

6   University. It helps students solve various word-based algebraic and geometric

7   problems with real-time feedback as students perform their tasks. The software

8   predicts human behavior, makes recommendations, and tracks student-user

9   performance in real time. The software is sold by Carnegie Learning.

10

11   <u>Limitations of the Prior Art</u>

12   Many internet/web sites do not offer a truly personalized experience. In their

13   systems, each student-user answers the same 10 questions (for example),

14   regardless of whether they answer the first questions correctly or incorrectly.

15   These are examples of non-intelligence, or limited intelligence, backed by a

16   linear, not relational, curriculum.

17

18   Other offline products (like CD-ROMs) have the ability to provide a somewhat

19   personalized path, depending on questions answered correctly or incorrectly, but

20   their number of questions is limited to the storage capacity of the CD-ROM. CD-

21   ROMs and off-line products are also not flexible to real-time changes to content.

1

2   CD-ROMs also must be installed on a computer. Some may only work with

3   certain computer types (e.g., Mac or PC), and if the computer breaks, one must re-

4   install it on another machine, and start all over with the product.

5

6   <u>The Present Solution to the Problem</u>

7   The present invention solves the aforementioned limitations of the prior art. The

8   present invention is intended to fill in the gaps of what schools cannot provide—

9   an individualized curriculum that is driven by the child's own learning pace and

10   standards. The major goal is to use the invention to help each child build a solid

11   foundation in the subject as early as possible, and then move on to more difficult

12   material. The present invention is an intelligent, adaptive system that takes in

13   information and reacts to the specific information given to it, using a set of

14   predefined heuristics. Therefore, each individual's information (which can and is

15   unique) will feed the engine, and then provide a unique experience to that

16   individual. One embodiment of the present invention discussed herein focuses on

17   Mathematics however the invention is not limited thereby as the same logic can

18   be applied to other academic subjects.

19

20   In accordance with one aspect of the present invention, there is provided, based

21   on a curriculum chart with correlation coefficients and prerequisite information,

1   unlimited curriculum paths that respond to students' different learning patterns

2   and pace. Topics are connected with each other based on pre-requisite/post-

3   requisite relationship thus creating a complex 3-D curriculum web. Each

4   relationship is also quantified by a correlation coefficient. Each topic contains a

5   carefully designed set of questions in increasing difficulty levels (e.g., 1-100).

6   Thus, without acquiring a certain percentage of pre-requisites, a student-user will

7   be deemed not ready to go into a specific topic.

8

9   In a second aspect of the present invention, all of the programming for the

10   heuristics and the logic is done in the Java programming language. In addition,

11   the present invention has been adapted to accept information, via the Internet,

12   using a browser as a client. Furthermore, information is stored in a database, to

13   help optimize the processing of the information.

14

15   Certain features and advantages of the present invention include: a high level of

16   personalization, continuous programs accessible anytime and anywhere, real-time

17   performance tracking systems that allow users, e.g., parents to track progress

18   information online, a relational curriculum, enabling individualized paths from

19   question to question and from topic to topic, worldwide comparison mechanisms

20   that allow parents to compare child performance against peers in other locations.

21

1　　The above aspects, features and advantages of the present invention will become

2　　better understood with regard to the following description.

3

4

5　　BRIEF DESCRIPTION OF THE DRAWING(S)

6　　Referring briefly to the drawings, embodiments of the present invention will be

7　　described with reference to the accompanying drawings in which:

8

9　　Figures 1 – 15 depict various aspects and features of the present invention in

10　　accordance with the teachings expressed herein.

11

12　　DETAILED DESCRIPTION OF THE PRESENT INVENTION

13　　Although what follows is a description of a preferred embodiment of the

14　　invention, it should be apparent to those skilled in the art that the following is

15　　illustrative only and not limiting, having been presented by way of example only.

16　　All the features disclosed herein may be replaced by alternative features serving

17　　the same purpose, and equivalents of similar purpose, unless expressly stated

18　　otherwise. Therefore, numerous other embodiments of the modifications thereof

19　　are contemplated as falling within the scope of the present invention. However,

20　　all specific details may be replaced with generic ones. Furthermore, well-known

1   features have not been described in detail so as not to obfuscate the principles

2   expressed herein.

3

4   Moreover, the techniques may be implemented in hardware or software, or a

5   combination of the two. In one embodiment, the techniques are implemented in

6   computer programs executing on programmable computers that each include a

7   processor, a storage medium readable by the processor (including volatile and

8   non-volatile memory and/or storage elements), at least one input device and one

9   or more output devices. Program code is applied to data entered using the input

10 device to perform the functions described and to generate output information.

11 The output information is applied to one or more output devices.

12

13 Each program is preferably implemented in a high level procedural or object

14 oriented programming language to communicate with a computer system,

15 however, the programs can be implemented in assembly or machine language, if

16 desired. In any case, the language may be a compiled or interpreted language.

17

18 Each such computer program is preferably stored on a storage medium or device

19 (e.g., CD-ROM, NVRAM, ROM, hard disk, magnetic diskette or carrier wave)

20 that is readable by a general or special purpose programmable computer for

21 configuring and operating the computer when the storage medium or device is

1   read by the computer to perform the procedures described in this document. The

2   system may also be considered to be implemented as a computer-readable storage

3   medium, configured with a computer program, where the storage medium so

4   configured causes a computer to operate in a specific and predefined manner.

5

6   The engine and the algorithms and methodology that it was developed for, is

7   currently specific for Mathematics at this time. But, using the same structure, it

8   can be broadened and used in any numbers of scenarios. The function of the

9   engine is primarily to react on information, or data, given to it. Then, based on a

10   set of rules or governing heuristics, it will react to the data, and provide

11   meaningful output. This ideology can be used in a number of different

12   applications.

13

14   Figures 1 and 2 illustrate exemplary hardware configurations of a processor-

15   controlled system on which the present invention is implemented. One skilled in

16   the art will appreciate that the present invention is not limited by the depicted

17   configuration as the present invention may be implemented on any past, present

18   and future configuration, including for example,

19   workstation/desktop/laptop/handheld configurations, client-server configurations,

20   n-tier configurations, distributed configurations, networked configurations, etc.,

21   having the necessary components for carrying out the principles expressed herein.

1

2   In its most basic embodiment however, Figure 1 depicts a system 700 comprising,

3   but not limited to, a bus 705 that allows for communication among at least one

4   processor 710, at least one memory 715 and at least one storage device 720. The

5   bus 705 is also coupled to receive inputs from at least one input device 725 and

6   provide outputs to at least one output device 730. The at least one processor 710 is

7   configured to perform the techniques provided herein, and more particularly, to

8   execute the following exemplary computer program product embodiment of the

9   present invention. Alternatively, the logical functions of the computer program

10   product embodiment may be distributed among processors connected through

11   networks or other communication means used to couple processors. The

12   computer program product also executes under various operating systems, such as

13   versions of Microsoft Windowsä, Apple Macintoshä, UNIX, etc. Additionally, in

14   a preferred embodiment, the present invention makes use of conventional

15   database technology 740 such as that found in the commercial product SQL

16   Server® which is marketed by Microsoft Corporation, to store, among other

17   things, the body of questions. Figures 3-8 illustrate one such order data

18   organization comprising Learning Dimensions, Proficiency Levels, Topics,

19   Questions, etc..

20

21

1   As shown in Figure 2, in another embodiment, the present invention is

2   implemented as a networked system having at least one client (e.g., desktop,

3   workstation, laptop, handheld, etc) in communication with at least one server

4   (e.g., application, web, and/or database servers, etc.,) via a network, such as the

5   Internet.

6

7   The present invention utilizes a comprehensive curriculum map that outlines

8   relational correlations between distinct base-level categories of mathematical

9   topics, concepts and skill sets.

10

11   The present invention generates an individually tailored curriculum for each user,

12   which is a result of the user's unique progression through the curriculum map, and

13   is dynamically determined in response to the user's ongoing performance and

14   proficiency measurements within each mathematical topic category. To illustrate

15   the mechanisms behind this process, attention must first be paid to the

16   mathematical topic category entity itself and its many features.

17

18   Each of the distinct mathematical topic category entities defined on the

19   curriculum map is represented technically as an object, with a vast member

20   collection of related exercise questions and solutions designed to develop skills

21   and proficiency in the particular topic represented. Each category object also

1   maintains a Student-user Proficiency Level measurement that continually

2   indicates each user's demonstrated performance level in that particular category.

3   In addition, each category object also maintains a Question Difficulty Level that

4   determines the difficulty of any questions that may be chosen from the object's

5   question collection and presented to the user. As expected, the movement of an

6   object's Question Difficulty Level is directly correlated to the movement of the

7   Student-user Proficiency Level. Referring to Figure 9, conceptually, each

8   category object may be depicted as a container, for example a water bucket. With

9   this analogy, the height of the water level within each bucket could then represent

10   the Student-user Proficiency Level, rising and falling accordingly. Directly

11   correlated to the water level, the Question Difficulty Level may then be

12   represented by graduated markings along the height of the bucket's inner wall,

13   ranging from low difficulty near the bottom to high difficulty near the top. The

14   rise and fall of the water level would therefore relate directly to the markings

15   along the bucket's wall.

16

17   As a student-user answers questions from a particular bucket, their Proficiency

18   Level in that topic area is gleaned from the accuracy of each answer, as well as

19   their overall performance history and consistency in the category. In general, a

20   correct answer will increase the user's proficiency measurement in that category,

21   while an incorrect answer will decrease it. A bucket's water level therefore

1 responds to each of the user's attempts to solve a question from that bucket's

2 collection. The issue left unresolved here is the incremental change in height

3 applied to the bucket's water level with each answered question.

4

5 On a per question basis, the magnitude of the incremental change in Proficiency

6 Level should vary, and will be determined by the user's recent performance

7 history in the category, specifically the consistency of their demonstrated

8 competence on previous questions from that bucket. Hence, a student-user who

9 has answered most questions in a category correctly will be posed with

10 progressively larger incremental increases in their Proficiency Level for an

11 additional correct answer, and progressively smaller incremental decreases for an

12 additional incorrect answer. The opposite conditions apply to a student-user that

13 has answered most questions in a category incorrectly. A student-user whose

14 performance history sits on the median will face an equally-sized increase or

15 decrease in Proficiency Level for their next answer.

16

17 The bucket property that will track and update a user's performance history is the

18 Student-user State rating. This rating identifies a user's recent performance

19 history in a particular bucket, ranging from unsatisfactory to excellent

20 competence. A student-user may qualify for only one State rating at a time. Each

21 State rating determines the magnitude of incremental change that will be applied

1   to a user's Proficiency Level in that bucket upon the next answered question, as

2   discussed in the previous paragraph. The user's performance on the next question

3   will then update the user's recent performance history, and adjust the user's State

4   accordingly before the next question is presented. In terms of the water bucket

5   analogy, a user's State may be illustrated as a range of cups, each of a different

6   size, which can add and remove varying amounts of water to and from the bucket.

7   Before answering each question from a bucket, a student-user is equipped with a

8   particular cup in one hand for adding water and a particular cup in the other hand

9   for removing water, depending on the user's State. The potential incremental

10   change in water level per question is therefore determined based on the user's

11   State. As the user's State rating changes, so do the cup sizes in the user's hands.

12

13   Revisiting the discussed functionality of the Proficiency Level in each bucket, it

14   becomes apparent that the full range of the Proficiency scale must be finite, and

15   therefore some other mechanisms must come into play once a user's Proficiency

16   Level in a bucket approaches the extreme boundaries of its defined range. It

17   would be nonsensical to continue adding water to a bucket that is filled to the

18   brim, or removing water from an empty bucket. Instead, approaching these

19   extreme scenarios should trigger a specialized mechanism to either promote or

20   demote the user's focus appropriately to another bucket. This is in fact the case,

21   and the new mechanisms that take over in these situations will lead the discussion

1   into inter-bucket relationships and traversing the curriculum map's links between

2   multiple buckets.

3

4   If a user's Proficiency Level in a particular bucket reaches a high enough level,

5   the student-user then qualifies to begin learning about content and attempting

6   questions from the "next" category bucket defined on the curriculum map.

7   Likewise, if a student-user demonstrates insufficient competence in a particular

8   bucket, their Proficiency Level in that bucket drops to a low enough level to begin

9   presenting the student-user with questions from the "previous" category bucket

10   defined on the curriculum map. These upper and lower Proficiency Threshold

11   Levels determine transitional events between buckets and facilitate the

12   development of a user's personalized progression rate and traversal paths through

13   the various conceptual categories on the curriculum map.

14

15   The direct relationships between category buckets on the curriculum map are

16   defined based on parallel groupings of similar level concept topics, and

17   prerequisite standards between immediately linked buckets of consecutive parallel

18   groups. These relationships help to determine the general progression paths that

19   may be taken from one bucket to the "next" or "previous" bucket in a curriculum.

20   Beyond the simple path connections, buckets that are immediately linked in the

21   curriculum map also carry a Correlation Index between them, which indicates

1   how directly the buckets are related, and how requisite the "previous" bucket's

2   material is to learning the content of the "next" bucket. These metrics not only

3   determine the transition process between buckets, but also help to dynamically

4   determine the probability of selecting questions from two correlated buckets as a

5   student-user gradually traverses from one to the other (this selection functionality

6   will be addressed shortly under the Question Selection Algorithm section).

7

8   Briefly summarizing, there are several levels of mechanisms operating on the

9   curriculum map, both within each category bucket as well as between related

10   category buckets. Within each bucket, a user's performance generates

11   Proficiency measurements, which set Difficulty Level ranges that ultimately

12   determine the difficulty levels of questions selected from that particular category.

13   Between related buckets, directly relevant topics are connected by links on the

14   curriculum map, and characterized by Correlation Indexes that reflect how

15   essential one topic is to learning another.

16

17

1   The present invention is a network (e.g., web-based) computer program product

2   application comprising one or more client and server application modules. The

3   client side application module communicates with the server side application

4   modules, based on student-user input/interaction.

5

6   In one exemplary embodiment of the present invention, the client tier comprises a

7   web browser application such as Internet Explorer™ by Microsoft™, and more

8   specifically, a client application based on Flash animated graphics technology and

9   format by Macromedia™.

10

11   In one exemplary embodiment of the present invention, the server tier comprises a

12   collection of server processes including a Knowledge Assessment Test module, a

13   Topic Selection module, and a Question Selection module. (collectively also

14   called "Engine"), discussed below.

15

16

1   KNOWLEDGE ASSESSMENT MODULE

2

3   The Knowledge Assessment component has the following objectives:

4   ·   To efficiently identify for each student-user the most appropriate starting

5   topic from a plurality of topics.

6   ·   To gauge student-user knowledge level across different learning

7   dimensions.

8

9   The Knowledge Assessment comprises 3 phases:

10   ·   Phase 1 consists of several questions (e.g., 5-10) purely numerical

11   questions designed to assess the user's arithmetic foundations.

12   ·   Phase 2 consists of a dynamic number (depending on user's success) of

13   word problem-oriented numerical questions designed to gauge the user's

14   knowledge of and readiness for the curriculum. The aim of Phase 2 is to quickly

15   and accurately find an appropriate starting topic for each user.

16   ·   Phase 3 consists of several questions (e.g., 10-20) word problem-oriented

17   questions designed to test the user's ability in all other learning dimensions. If the

18   student-user exhibits particularly poor results in Phase 3, more questions may be

19   posed

20

21   **Initial Test Selection**

1

2   In one embodiment, to enhance the system's intelligence, the system prompts the

3   student-user for date of birth and grade information. After entering the requested

4   date of birth and grade information, the system prompts the student-user with one

5   of several (e.g., six) Phase 1 Tests, based on the following calculation:

6

7   Date of Birth is used to compute Age according to the following formula:

8

9   SecondsAlive = Number of seconds since midnight on the user's Date of

10   Birth

11   Age = Floor(SecondsAlive ÷ 31556736)

12

13   Grade is an integer between 1 and 12.

14

15   The system determines an appropriate Test Number as follows: note that where

16   grade and/or date of birth data is missing, the system uses predetermined logic.

17

18   If no data is known (Note: this case should not happen), then Test Number = 1

19

20   If only date of birth is known, then Test Number = max{ 1, min{ Age − 5 , 6 } }

21

1   If only grade is known (Note: this case should not happen), then Test Number =

2   min{ Grade , 6 }

3

4   If both date of birth and grade are known, then Test Number = min{ Floor([(2 x

5   Grade) + (Age – 5)] ÷ 3) , 6 }

6

7   **Test Jumps**

8

9   Depending on the user's progress or level of proficiency, the student-user may

10   jump from one test to another.

11

12

13   *Test Jump Logic*

14

15   If the student-user answers a certain number of consecutive questions correctly

16   (incorrectly), the student-user will jump up (down) to the root node of the next

17   (previous) test. The requisite number depends on the particular test and is hard-

18   coded into each test. For example, a student-user starting in Test 1 must answer

19   the first four Phase 2 questions correctly in order to jump to Test 2.

20

21   *Test Jump Caps*

1

2   If the student-user jumps up (down) from one Test to another, in one embodiment,

3   the system will prevent the student-user from jumping back down (up) in the

4   future to revisit a Test.

5

6   In another embodiment, the student-user may revisit a Test however, the user's

7   starting topic is set to the highest topic answered successfully in the lower level

8   Test. For example, referring to Figure 2, if the student-user jumps from Test 1 to

9   Test 2, and then subsequently falls back to Test 1, the starting topic is set at the

10   01N05 test, Phase 2 ends, and Phase 3 of the 01N05 test begins.

11

12   **Test Progression**

13

14   In one embodiment, a student-user proceeds through the Knowledge Assessment

15   module linearly, beginning with Phase 1 and ending with Phase 3. Phase 1 and

16   Phase 2 are linked to specific test levels. Phase 3 is linked to a specific Number

17   topic, namely the Number topic determined in Phase 2 to be the user's starting

18   topic. Two users who start with the same Phase 1 test will take at least part of the

19   same Phase 2 test (though depending on their individual success, one may surpass

20   the other and see more questions), but may take very different Phase 3 tests

21   depending on their performance in Phase 2.

1

2   Knowledge Assessment Question Selection Approach

3

4   Each Knowledge Assessment question tests one or both of two skills: word

5   problem-solving skill, and skill in one of the five other learning dimensions. The

6   following variables are used for scoring purposes:

7

8   NScore – A running tally of the number of Number-related questions the student-

9   user has answered correctly.

10   NTotal – A running tally of the number of Number-related questions the student-

11   user has attempted.

12   PScore – A running tally of the number of Problem Solving-related questions the

13   student-user has answered correctly.

14   PTotal – A running tally of the number of Problem Solving-related questions the

15   student-user has attempted.

16   PSkill – Codes whether the question tests proficiency in Word Problems. In

17   general, will be set to 0 for Phase 1 questions, and to 1 for Phase 2 and Phase 3

18   questions

19

20   At the beginning of the Knowledge Assessment, all four of these variables are

21   initialized to zero.

1

2   **Assessments Test Phases**

3   The various assessments tests consists of three phases, namely Phase 1, Phase 2

4   and Phase 3.

5

6   **Phase 1**

7

8   *Overview*

9   Phase 1 is used to assess the user's foundation in numerical problems.

10   Phase 1 consists of a predetermined number (e.g., 5-10) of hard-coded questions.

11   The system presents the questions to the student-user in a linear fashion..

12

13   *Phase 1 Logic:*

14   1.   If the student-user answers a question correctly:

15   a.   NScore is increased by 1.

16   b.   NTotal is increased by 1.

17   c.   The student-user proceeds to the next question referenced in the

18   question's   "Correct" field.

19

20   2.   If the student-user answers a question incorrectly:

21   a.   NScore is not affected.

1   b.   NTotal is increased by 1.

2   c.   The student-user proceeds to the next question referenced in the

3   question's   "Incorrect" field.

4

5 **Phase 2**

6 *Overview*

7

8 Phase 2 establishes the user's starting topic. Phase 2 follows a binary tree

9 traversal algorithm. See Figure #. Figure # depicts an exemplary binary tree

10 representing Phase 2 of an Assessment Test 1. The top level is the root node. The

11 bottom level is the placement level, where the user's starting topic is determined.

12 All levels in between are question levels. Nodes that contain pointers to other

13 Tests (indicated by a Test level and Phase number)(See #) are called jump nodes.

14 Each Test Level Phase 2 tree looks look similar to Figure # with varying tree

15 depths (levels).

16

17 An exemplary Phase 2 binary tree traversal algorithm is as follows:

18

19   Leftward movement corresponds to a correct answer. Rightward

20 movement corresponds to an incorrect answer.

1 ·   The topmost topic is the root node. This is where the student-user starts

2 after finishing Phase 1. At the root node, the student-user is asked two questions

3 from the specified topic. This is the only node at which two questions are asked.

4 At all other nodes, only one question is asked.

5 ·   At the root node, the student-user must answer both questions correctly to

6 register a correct answer for that node (and hence move leftward down the tree).

7 Otherwise, the student-user registers and incorrect answer and moves rightward

8 down the tree.

9 ·   The student-user proceeds in this manner down through each question

10 level of the tree.

11 ·   The student-user proceeds in this manner until he reaches the placement

12 level of the tree. At this point, he either jumps to Phase 1 of the specified test (if

13 he reaches a jump node) or the system registers a starting topic as indicated in the

14 node.

15

16 *Phase 2 Logic:*

17 1.   If the student-user answers a question correctly:

18   a.   NScore increases by 1.

19   b.   NTotal increases by 1.

20   c.   If the question's Pskill is set to 1, then

21   i.   PScore increases by 1.

1   ii.   PTotal increases by 1.

2   d.   Else if the question's PSkill is set to 0, then

3   i.   PScore is unaffected.

4   ii.   PTotal is unaffected.

5   e.   The student-user proceeds to the next question referenced in the

6 question's "Correct" field.

7   2.   If the student-user answers a question incorrectly:

8   a.   NScore is unaffected.

9   b.   NTotal increases by 1.

10   c.   If the question's PSkill is set to 1, then

11   i.   PScore is unaffected.

12   ii.   PTotal increases by 1.

13   d.   Else if the question's PSkill is set to 0, then

14   i.   PScore is unaffected.

15   ii.   PTotal is unaffected.

16   e.   The student-user proceeds to the next question referenced in the

17 question's "Incorrect" field.

1   **Phase 3**

2

3   Phase 3 is designed to assess the user's ability in several learning dimensions

4   (e.g., the Measure (M), Data Handling (D), Shapes and Space (S), and Algebra

5   (A) learning dimensions) at a level commensurate with the user's starting Number

6   topic determined in Phase 2. Phase 3 consists of a predetermined number of

7   questions (e.g., 9-27) hard-coded to each starting Number topic. For example, if

8   the user's starting Number topic is determined in Phase 2 to be 01N03, then the

9   student-user is presented with an corresponding 01N03 Phase 3 test.

10

11   The Knowledge Assessment lookup tables contain 3 questions from each M, D, S,

12   and A learning dimensions in the PLANETii curriculum.

13

14   Each Phase 3 test pulls questions from between 1 and 3 topics in each learning

15   dimension.

16

17   *Phase 3 Logic:*

18

19   1.   If the student-user answers a question correctly:

20   a.   If the question's PSkill is set to 1, then

21   i.   PScore increases by 1.

1   ii.   PTotal increases by 1.

2   b.   Else if the question's PSkill is set to 0, then

3   i.   PScore is unaffected.

4   ii.   PTotal is unaffected.

5   c.   The student-user proceeds to the next question referenced in the

6   question's "Correct" field.

7   2.   If the student-user answers a question incorrectly:

8   a.   If the question's PSkill is set to 1, then

9   i.   PScore is unaffected.

10   ii.   The PTotal increases by 1.

11   b.   Else if the question's PSkill is set to 0, then

12   i.   PScore is unaffected.

13   ii.   The PTotal is unaffected.

14   c.   The student-user proceeds to the next question referenced in the

15   question's "Incorrect" field.

16

17 3.   If the student-user answered all three questions in any topic incorrectly,

18 the system provides a fallback topic at the end of Phase 3.

19

20   Each topic in the M, D, S, and A learning dimensions is coded with a fall-

21 back topic. If the student-user fails a topic, the student-user is given the

1   opportunity to attempt the fallback topic. For example, if a student-user answers

2   all three questions in 03M01 (Length and Distance IV) incorrectly, after the

3   student-user completes Phase 3, the system prompts the student-user with a

4   suggestion to try a fallback topic, e.g., 01M03 (Length and Distance II).

5

6   DATA STORAGE OF KNOWLEDGE ASSESSMENT INFORMATION –

7   DATABASE ORGANIZATION

8

9   The content/questions used during the Knowledge Assessment module are

10   stored in a main content-question database. One or more look up tables are

11   associated with the database for indexing and retrieving knowledge assessment

12   information. Exemplary knowledge assessment lookup tables comprise the

13   following fields A-W and optionally fields X-Y:

14

15   Field A: AQID

16   Field A contains the Knowledge Assessment Question ID code (AQID). This

17   should include the Test level (01-06, different for Phase 3), Phase number (P1-

18   P3), and unique Phase position (see below). Each of the three Phases has a

19   slightly different labeling scheme. For example: 01.P1.05 is the fifth question in

20   Phase 1 of the Level 1 Knowledge Assessment; 03.P2.I1C2 is the third question

21   that a student-user would see in Phase 2 of the Level 3 Knowledge Assessment

1 following an Incorrect and a Correct response, respectively; and 01N03.P3.02 is

2 the second question in the 01N03 Phase 3 Knowledge Assessment.

3 Field B: QID

4 Field C: Topic Code

5 Field D: Index

6 Field E: PSL

7 Field F: Question Text

8 -Fields B-F are pulled directly from the main content-question database and are

9 used for referencing questions.

10 Field G: Answer Choice A Text

11 Field H: Answer Choice B Text

12 Field I: Answer Choice C Text

13 Field J: Answer Choice D Text

14 Field K: Answer Choice E Text

15 -Fields G-K contain the five possible Answer Choices (a-e).

16 Field L :   Correct Answer Text.

17 Fields M-Q contain Incorrect Answer Explanations corresponding to the Answer

18 Choices in fields G-K. The field corresponding to the correct answer is grayed-

19 out.

20 Field R: Visual Aid Description - The Visual Aid Description is used by

21 Content to create Incorrect Answer Explanations.

1 Field S: Correct – A pointer to the QID of the next question to ask if the

2 student-user answers the current question correctly.

3 Field T: Incorrect – A pointer to the QID of the next question to ask if the

4 student-user answers the current question incorrectly.

5 Field U: NSkill – 0 or 1. Codes whether the question involves Number skill.

6 Used for scoring purposes.

7 Field V: PSkill – 0 or 1. Codes whether the question involves Word

8 problem skill. In general, will be set to 0 for Phase 1 questions, and to 1 for Phase

9 2 and Phase 3 questions. Used for scoring purposes.

10 Field W: LDPoint – 1, 1.2, or 1.8 points for questions in Phase 3, blank for

11 questions in Phase 1 and Phase 2. Depends on PSL of question and is used for

12 evaluation purposes.

13 Field X: Concepts – Concepts related to the question material. May be used

14 for evaluation purposes in the future.

15 Field Y: Related Topics – Topics related to the question material. May be

16 used for evaluation purposes in the future.

17

18

1   FORMULAS FOR TEST SCORING

2

3   During the Knowledge Assessment Test module, the system calculates several

4   scores as follows:

5

6   The user's number score in the Numbers learning dimension is calculated via the

7   following formula:

8

9    $\text{Number Score} = \min[\ \text{Floor}\{[\text{NScore} / (\text{NTotal} - 1)] * 5\}, 5\ ]$

10

11   The user's score in other learning dimensions (e.g., Measure, Data Handling,

12   Shapes and Space and Algebra) is calculated as follows:

13

14   First, a score is computed in each topic. In each Measure, Data Handling,

15   Shapes and Space and Algebra learning dimension, there are three questions, one

16   each with a LDPoint value of 1, 1.2, and 1.8. The user's topic score is calculated

17   via the following formula:

18

19    $\text{Topic Score} = \text{Round}\{\text{Sum of LDPoints of All 3 Questions} * (5/4)]\}$

20

1   All Topic Scores in a given Learning Dimension are averaged (and floored) to

2   obtain the Learning Dimension Score.

3

4   Finally, the user's word problem score is calculated using the following formula:

5

6   Word Problem Score = min[Floor{[PScore / (PTotal − 1)] * 5}, 5]

7

8   EVALUATION OF KNOWLEDGE ASSESSMENT RESULTS

9

10   *Overview*

11   At the end of the Knowledge Assessment module, the system prompts the

12   student-user student-user to log out and the parent/instructor to log in to access

13   test results. The system then presents the parent/instructor with a screen relaying

14   the following evaluation information: 1) the name of each of the learning

15   dimensions (currently, five) in which the student-user student-user was tested is

16   listed, along with a 0-5 scale displaying the user's performance and 2) the user's

17   "Word Problem Skill" is assessed on a 0-5 scale.

18

19   The parent/instructor can then select a learning dimension or the "Word

20   Problem Skill" to see all relevant questions attempted by the student-user user,

21   along with incorrect answers and suggested explanations.

1

2   *Evaluation Standards*

3   Using an exemplary 0-5 scale, a 5 corresponds to full proficiency in a

4   topic. If a student-user scores a 5 in any learning dimension or in word problem

5   solving, the system displays the following message: "[Child Name] has

6   demonstrated full proficiency in [Topic Name]."

7

8   A 3-4 corresponds to some ability in that topic. If a student-user scores a

9   3-4 in any learning dimension or in word problem-solving, the system displays

10   the following message: "[Child Name] has demonstrated some ability in [Topic

11   Name]. PLANETii system will help him/her to achieve full proficiency."

12

13   A 0-2 generally means that the student-user is unfamiliar with the topic

14   and needs to practice the material or master its prerequisites.

15

16   Full proficiency in a topic is defined as ability demonstrated repeatedly in

17   all questions in the topic. In the current implementation described herein, a

18   student-user has full proficiency only when he/she answers every question

19   correctly.

20

1   Some ability in a topic is defined as ability demonstrated repeatedly in a

2   majority of questions in the topic. In the current implementation, the student-user

3   must answer 2 of 3 questions in any topic correctly.

4

5

6   INITIALIZATION OF WATER LEVELS

7

8   After completion of the Knowledge Assessment Test module, the water

9   levels of the user's starting topic, any pre-requisites and related topics are

10   initialized (pre-assigned values) according to the following logic:

11·

12   ■   The water level in the user's starting topic is not initialized.

13   ■   The water level in any Number topics that are pre-requisites (with a high

14   correlation coefficient (NEW) to the user's starting topic is initialized to

15   85.

16   ■   For the other learning dimensions, topics are organized into subcategories.

17

18 Consider the following example where one family of topics organized into related

19 sub-topic categories include:

20   1.   01M01 Length and Distance I

21   2.   01M03 Length and Distance II

1   3.   02M01 Length and Distance III

2   4.   03M01 Length and Distance IV

3   Suppose a user, after completing the Knowledge Assessment Test module, is

4   tested in topic 03M01 Length and Distance IV: if his/her topic score in 03M01

5   Length and Distance IV is 5, then a). the water level in 03M01 Length and

6   Distance IV is set to 85 and b) the water level in related topics 01M01 Length and

7   Distance I, 01M03 Length and Distance II, 02M01 02M01 Length and Distance

8   III is set to 85.

9   If his/her topic score in 03M01 Length and Distance IV is 4, then a) the

10   water level in 03M01 Length and Distance IV is set to 50; and b) the water level

11   in related topics 01M01 Length and Distance I, 01M03 Length and Distance II,

12   02M01 Length and Distance III is set to 85.

13   If his/her topic score in 03M01 Length and Distance IV is 3 or below, then

14   a) the water level in 03M01 Length and Distance IV is not initialized; b) the water

15   level in related topic 02M01 Length and Distance III is not initialized; and c) the

16   water level in any related topic in the subcategory at least twice removed from

17   03M01 Length and Distance IV (in this case, 01M01 Length and Distance I and

18   01M03 Length and Distance II) is initialized to 85.

19   The water level for a given topic can be assigned during initialization or

20   after a student-user successfully completes a topic. Thus, a pre-assigned water

21   level of 85 during initialization is not the same as an earned water level of 85 by

1   the user. Therefore, a student-user can fall back into a topic with a pre-assigned

2   water level of 85 if need be.

3

4   TOPIC SELECTION ALGORITHM MODULE

5

6   The Topic Selection module is a three step multi-heuristic intelligence algorithm

7   which assesses the eligibility of topics and then ranks them based on their

8   relevance to a given student's past performance. During step one, the Topic

9   Selection module prunes (culls) the list of uncompleted topics to exclude those

10   topics which are not relevant to the student's path and progress. During step two,

11   the Topic Selection module evaluates each eligible topic for relevance using the

12   multi-heuristic ranking system. Each heuristic contributes to an overall ranking of

13   relevance for each eligible topic and then the topics are ordered according to this

14   relevance. During step three, the Topic Selection module assesses the list of

15   recommendations to determine whether to display the recommended most

16   relevant topics.

17

18   FIG. 11 depicts an exemplary process flow for the Topic Selection Algorithm

19   module.

20

21   *Step 1 - Culling eligible topics*

1

2   The Topic Selection module employs several culling mechanisms which

3   allow for the exclusion of topics based on the current state of a user's curriculum.

4   The topics that are considered eligible are placed in the list of eligible topics.

5   The first step includes all topics that have an eligibility factor greater than 0, a

6   water level less than 85 and no value from the placement test. This ensures that

7   the student-user will not enter into a topic that they are not ready for or one that

8   they have already completed or tested out of. The last topic a student-user

9   answered questions in is explicitly excluded from the list which prevents the

10   engine from recommending the same topic twice in a row particularly if the

11   student-user fails out of the topic.

12   After these initial eligibility assertions take place, some additional considerations

13   are made. If there are any topics that are current failed in the user's curriculum, all

14   of the uncompleted pre-requisites of these topics are added to the eligible list.

15   This includes topics that received values from the placement test.

16   Finally, if there are no failed topics in the student's curriculum and all the topics

17   in the recommendation list that are greater than 1 level away from the student's

18   average level, the list is cleared and no topics are included. This will indicate a

19   "Dead End" situation.

20

21   *Step 2 - Calculating Relevance*

1

2   After the list of eligible topics has been compiled, the Topic Selection module

3   calculates a relevance score for each topic. The relevance score is calculated

4   using several independent heuristic functions which evaluate various aspects of a

5   topic's relevance based upon the current state of the user's curriculum. Each

6   heuristic is weighted so that the known range of its values can be combined with

7   the other heuristics to provide an accurate relevance score. The weights are

8   designed specifically for each heuristic so that one particular relevance score can

9   cancel or compliment the values of other heuristics. The interaction between all

10   the heuristics creates a dynamic tension in the overall relevance score which

11   enables the recognition of the most relevant topic for the student-user based on

12   their previous performance.

13

14   *Relevance Heuristics Explained*

15

16   1) Average Level Relevance

17   Overview:

18   This heuristic determines a student's average overall level and then

19   rewards topics which are within a one-level window of the average while

20   punishing topics that are further away.

21

1   Formula:

2   For each level:

3

4   LevelAverage = sum(topicWaterLevel * topicLevel) / sum(topicLevel)

5   Average Level = Sum(LevelAverage)

6   Topic relevance: (0.5 - ABS(topicLevel - Average Level)) * 5

7

8   Range of Possible Values:

9   (in current curriculum 1-4): 2.5 to -17.5

10

11   Weighted Range of Possible Values:

12   (in current curriculum 1-4): 7.5 to -52.5

13

14   2) Eligibility Relevance

15   Overview:

16   This heuristic assesses the student's readiness for the topic, found by determining

17   how much of each direct pre-requisite a student-user has completed.

18

19   Formula:

20

21   If W(PrqN) ³ 85, then set W(PrqN) = 85;

1

2

3

4   wherein: $E(X)$ be the Eligibility Index of Bucket X,

5                  $W(PrqN)$ be the Water Level of Pre-requisite N of Bucket X

6                  $Cor(X, PrqN)$ be the Correlation Index between Bucket X and its

7   Pre-requisite N, where N is the number of pre-requisite buckets

8   for X

9   t be the constant 100/85

10

11   Range of Possible Values:

12   (in current curriculum 1-4): 100 to 0

13

14   Weighted Range of Possible Values:

15   (in current curriculum 1-4): 20 to 0

16

17   3) Concept Importance (Static Multiplier) Relevance

18   Overview:

19   Concept importance is a predetermined measure of how important a topic is. For

20   example, a topic like "Basic Multiplication" is deemed more important than "The

21   Four Directions."

1

2   Formula:

3   1 - (Topic Multiplier)

4

5   Range of Possible Values:

6   (in current curriculum 1-4): 1 to 0

7

8   Weighted Range of Possible Values:

9   (in current curriculum 1-4): 5 to 0

10

11   4) Contribution Relevance

12   Overview:

13   This heuristic measures the potential benefit completing this topic would provide,

14   by adding its post-requisites' correlations.

15

16   Formula:

17   SUM(post requisite correlation)

18

19   Range of Possible Values:

20   (in current curriculum 1-4): ~6 to 0

21

1   Weighted Range of Possible Values:

2   (in current curriculum 1-4): ~3 to 0

3

4   5) Learning Dimension Repetition Relevance

5   Overview:

6   This heuristic is meant to ensure a degree of coherence to the student-user while

7   developing a broad base in multiple learning dimensions. The heuristic favors 2

8   consecutive topics in a particular learning dimension, and then gives precedence

9   to any other learning dimension, so a student-user doesn't overextend his/her

10   knowledge in any one learning dimension.

11

12   Formula:

13   This heuristic uses a lookup table (see below) of values based on the number of

14   consecutive completed topics in a particular learning dimension.

15

16

17

1) Repetitions	2) 0	3) 1	4) 2	5) 3	6) 4	7) 5	8) 6	9) 7	10) 8
11) Value	12) 2	13) 7.5	14) -1	15) -5	16) -9	17) -12	18) -17	19) -22	20) -27

18

19

20

21

1   Range of Possible Values:

2   (in current curriculum 1-4): 7.5 to -27.5

3

4   Weighted Range of Possible Values:

5   (in current curriculum 1-4): 9.38 to -34.375

6

7   6) Failure Relevance

8   Overview:

9   This heuristic gives a bonus to topics that are important pre-requisites to

10   previously failed topics. For example, if a student-user fails 01M01 (Length and

11   Distance I), then the pre-requisites of 01M01 will receive a bonus based on their

12   correlation to 01M01. It treats assessment test topics differently than the normal

13   unattempted topics and weights the bonuses it gives to each according to the

14   balance of the correlation between these prerequisites. For example, an

15   assessment test topic's correlation to the failed topic must be higher than the sum

16   of the other unattempted topics or it receives no bonus. All unattempted topics

17   receive a bonus relative to their correlation to the failed topic.

18

19   Formula:

20   get the kid/bucket data

21   loop through the failed topics

1   get this failed topic ID

2   get the topic data for the failed topic ID

3   if we are a pre-req of the failed topic

4   sum the unattempted pre-req buckets' correlations

5   if the AT topic's correlation is higher than the sum of the unattempted pre-reqs

6   add 5 + (5 * our correlation - the unattempted sum) to the bonus

7   otherwise return nothing

8   otherwise return 10 * the pre-req's correlation

9   return the bonus

10

11   Range of Possible Values:

12   (in current curriculum 1-4): 10 to 0

13

14   Weighted Range of Possible Values:

15   (in current curriculum 1-4): 10 to 0

16

17   7) Additional Failure (Re-Recommend) Relevance

18   Overview:

19   This heuristic promotes failed topics if the student-user has completed most of the

20   pre-requisite knowledge, and demotes topics for which a high percentage of the

1   pre-requisite knowledge has not been satisfied. If the last topic completed was a

2   pre-requisite of this failed topic, this topic receives a flat bonus.

3

4   Formula:

5   score += (80 - EI) / 10;

6   if(preReq.equals(EngineUtilities.getLastBucket(userId))) {score += 3;}

7

8   Range of Possible Values:

9   (in current curriculum 1-4): 11 to -2

10

11   Weighted Range of Possible Values:

12   (in current curriculum 1-4): 11 to -2

13

14   public double calculateRelevance(String userId, String topicId) {

15   double score = 0;

16   // get the kid/bucket data

17   KidBucketWrapper kbw = new KidBucketWrapper(userId, topicId);

18   // loop through the failed topics

19   for(Iterator i = curriculum.getFailedTopics(userId).iterator();i.hasNext();) {

20   // get this failed topic Id

21   String fTopicId = (String)i.next();

```
1     // get the Topic data for the failed topic id

2     Topic fTopic = curriculum.getTopic(fTopicId);

3     // if we are a pre-req of the failed topic

4     if(fTopic.getPreRequisite(topicId) != null) {

5     // if we are an AT topic

6     if(kbw.getAssessmentLevel() > 0) {

7     double preSum = 0;

8     // sum the unattempted pre-req buckets' corellations

9     for(Iterator i2 = fTopic.getPreRequisites();i2.hasNext();) {

10    String pre = (String)i2.next();

11    Topic preTopic = curriculum.getTopic(pre);

12    KidBucketWrapper prebw = new KidBucketWrapper(userId, pre);

13    If(!pre.equals(topicId) && prebw.getAssessmentLevel() == 0 &&

14    prebw.getWaterLevel() == 0) {

15    preSum+=preTopic.getPostRequisite(fTopicId).getCorrelationCoefficient();

16    }

17    }

18

19    // if the AT topic's corellation is higher than the sum of the unattempted pre-reqs

20    if(fTopic.getPreRequisite(topicId).getCorrelationCoefficient() > preSum) {

21    // add 5 + (5 * our correlation - the unattempted sum) to the bonus
```

```
1    score += 5 + (5 * (fTopic.getPreRequisite(topicId).getCorrelationCoefficient() -

2    preSum));

3    }

4    // otherwise return nothing

5    else {

6    return 0;

7    }

8    }

9    // otherwise return 10 * the pre-req's correlation

10   else {return 10 * fTopic.getPreRequisite(topicId).getCorrelationCoefficient();

11   }

12   }

13   }

14   // return the bonus

15   return score;

16   }

17

18   Step 3 – Assess Recommendations

19             During the third and final step, the system assesses the list of

20   recommendations to determine whether to display the recommended most

21   relevant topics.
```

1 ELIGIBILITY INDEX

2

3 The Eligibility Index represents the level of readiness for the bucket to be chosen.

4 In other words, we ask the question "How ready is the student-user to enter into

5 this bucket?" Hence, the Eligibility Index of a bucket is a measure of the total

6 percentage of pre-requisites being completed by the user. The Eligibility Index is

7 calculated as follow:

8

9 Let E(X) be the Eligibility Index of Bucket X,

10 Let W(PrqN) be the Water Level of Pre-requisite N of Bucket X

11 Let Cor(X, PrqN) be the Correlation Index between Bucket X and its Pre-requisite

12 N, where N is the number of pre-requisite buckets for X

13 Let t be the constant 100/85

14

15 If W(PrqN) ^{3} 85, then set W(PrqN) = 85;

16

17
18 $$E(X) = \frac{\sum\limits_{N} \left[t * W(Prq_N) * Cor(X, Prq_N) \right]}{\sum\limits_{N} Cor(X, Prq_N)}$$

19

20

1 To increase the effectiveness of choosing an appropriate bucket for the user, we

2 introduce a new criteria called Eligibility Index Threshold. If the eligibility index

3 does not reach the Eligibility Index Threshold, then the bucket is considered not

4 ready to be chosen.

5

6 Summary of Relevant Numbers for Implementation

7 1.   Question selection starts at Water Level 25 for any new bucket

8 2.   Proficiency Range (Water Level Range) is 0 to 100

9 3.   Lower Threshold = 10

10 4.   Upper Threshold = 85

11 5.   Force Jump Backward at Water Level 0

12 6.   Force Jump Forward at Water Level 100

13 7.   Eligibility Index Threshold = 80

14

15 *Ranking and special case recognition*

16

17 Once the relevance has been calculated for each eligible topic, the Topic Selection

18 module recommends the two most relevant topics. If there are no topics to

19 recommend (i.e the Culling phase eliminated all possible recommendations), one

20 of two states is identified. The first state is called "Dead Beginning" and occurs

21 when a student-user fails the 01N01 "Numbers to 10" topic. In this case, the

1   student-user is not ready to begin using the Smart Practice training and a message

2   instructing them to contact their parent or supervisor is issued. The second state

3   is called "Dead End" and occurs when a student-user has reached the end of the

4   curriculum or the end of the available content. In this case, the student-user has

5   progressed as far as possible and an appropriate message is issued.

6   QUESTION SELECTION MODULE

7

8   *Overview*

9   Once a topic has been determined for the student-user, the Question Selection

10 - Module delivers an appropriately challenging question to the student-user. In

11   doing so, the Question Selection Module constantly monitors the student-user's

12   current water level and locates the question(s) that most closely matches the

13   difficulty level the student-user is prepared to handle. Since water level and

14   difficulty level are virtually synonymous, this means that a student-user currently

15   at (for example) water level 56 should get a question at difficulty level 55 before

16   one at difficulty level 60. If the student-user answers the question correct, his/her

17   water level increases by an appropriate margin; if he/she answers incorrectly,

18   his/her water level will decrease.

19

20   Additionally, the Question Selection Module provides that all questions in a topic

21   should be exhausted before delivering a question the student-user has previously

1   answered. If all of the questions in a topic have been answered, the Question

2   Selection Module will search for and deliver any incorrectly answered questions

3   before delivering correctly answered questions. Alternatively and preferably, the

4   system will have an abundance of questions in each topic, therefore, it is not

5   anticipated that student-users will see a question more than once.

6   *Question Search Process*

7   All questions are each assigned a specific difficulty level from 1-100. Depending

8   on the capabilities of the system processor(s), the system may search all of the

9   questions for the one at the closest difficulty level to a student-user's current

10 water level. Alternatively, during the search process, the system searches within a

11 pre-set range around the student-user's water level. For example, if a student-

12 user's water level is 43, the system will search for all the questions within 5

13 difficulty levels (from 38 to 48) and will select one at random for the student.

14

15 The threshold for that range is a variable that can be set to any number. The

16 smaller the number, the tighter the selection set around the student's water level.

17 The tighter the range, the greater the likelihood of finding the most appropriate

18 question, but the greater the likelihood that the system will have to search

19 multiple times before finding any question.

20

21 General Flow

1   1.   Get the student's current water level

2   2.   Search the database for all questions within (+ or -) 5 difficulty levels of

3   the student's water level. (NOTE: This threshold + or – 5 can become tighter to

4   find more appropriate questions, but doing so will increase the demands on the

5   processor.)

6   3.   Serve a question at random from this set.

7   4.   Depending on the students answer, adjust his/her water level according to

8   the water level adjustment table.

9   5.   Repeat the process.

10

11 Governing Guidelines

12 1.   Questions should be chosen from difficulty levels closest the student's

13 current water·level. If no questions are found within the stated threshold (in our

14 example, + or – 5 difficulty levels), the algorithm will continue to look further and

15 further out (+ or – 10, + or – 15, and so on).

16 2.   A previously answered question should not be picked again for any

17 particular student-user unless all the possible questions in the topic have been

18 answered.

19 3.   If all questions in a topic have been answered, search for the closest

20 incorrectly answered question.

1   4.   If all questions have been answered correctly, refresh the topic and start

2   again.

3

4   Figure 15 depicts an exemplary process flow for picking a question from a

5   selected topic-bucket.

6

7   STATE LEVEL AND WATER LEVEL CALCULATIONS

8

9   A State Level indicates the student's consistency in performance for any bucket.

10   When a student-user answers a question correctly, the state level will increase by

11   1, and similarly, if a student-user answers incorrectly, the state level will decrease

12   by 1. Preferably, the state level has a range from 1 to 6 and is initialized at 3.

13

14   A Water Level represents a student's proficiency in a bucket. Preferably, the

15   water level has a range from 0 to 100 and is initialized at 25 when a student-user

16   enters a new bucket.

17

18   A Bucket Multiplier is pre-determined for each bucket depending on the

19   importance of the material to be covered in the bucket. The multiplier is applied

20   to the increments/decrements of the water level. If the bucket is a major topic, the

21   multiplier will prolong the time for the student-user to reach Upper Threshold. If

1   the bucket is a minor topic, the multiplier will allow the student-user to complete

2   the topic quicker.

3

4   To locate the corresponding water level from the user's current question to the

5   next question, the adjustment of the water level based on the current state of the

6   bucket is as follows:

7

State Level that the student-user is currently in:	Adjustment in water level when a question is answered correctly:	Adjustment of water level when a question is answered incorrectly:
1	+0m	-5m
2	+1m	-3m
3	+1m	-2m
4	+2m	-1m
5	+3m	-1m
6	+5m	-0m
m = Bucket Multiplier		

8

9

10   DATA TRANSFER

11

12   The communications are handled securely, using a 128-bit SSL Certificate signed

13   with a 1024-bit key. This is currently the highest level of security supported by

14   the most popular browsers in-use today.

15

1   The data that is exchanged between the client and server has 2 paths: 1) from the

2   server to the client, and 2) from the client to the server. The data sent from the

3   client to the server is sent as a POST method. There are two main ways to send

4   information from a browser to a web server, GET and POST. POST is the more

5   secure method. The data sent from the server to the client is sent via the

6   Extensible Markup Language (XML) format, which is widely accepted as the

7   standard for exchanging data. This format was chosen because of its flexibility,

8   and allows the system to re-use, change, or extend the data being used more

9   quickly and efficiently.

10

11   CONCLUSION

12   Having now described one or more exemplary embodiments of the invention, it

13   should be apparent to those skilled in the art that the foregoing is illustrative only

14   and not limiting, having been presented by way of example only. All the features

15   disclosed in this specification (including any accompanying claims, abstract, and

16   drawings) may be replaced by alternative features serving the same purpose, and

17   equivalents or similar purpose, unless expressly stated otherwise. Therefore,

18   numerous other embodiments of the modifications thereof are contemplated as

19   falling within the scope of the present invention as defined by the appended

20   claims and equivalents thereto.

21

1   Moreover, the techniques may be implemented in hardware or software, or a

2   combination of the two. In one embodiment, the techniques are implemented in

3   computer programs executing on programmable computers that each include a

4   processor, a storage medium readable by the processor (including volatile and

5   non-volatile memory and/or storage elements), at least one input device and one

6   or more output devices. Program code is applied to data entered using the input

7   device to perform the functions described and to generate output information.

8   The output information is applied to one or more output devices.

9

10   Each program is preferably implemented in a high level procedural or object

11   oriented programming language to communicate with a computer system,

12   however, the programs can be implemented in assembly or machine language, if

13   desired. In any case, the language may be a compiled or interpreted language.

14

15   Each such computer program is preferably stored on a storage medium or device

16   (e.g., CD-ROM, NVRAM, ROM, hard disk, magnetic diskette or carrier wave)

17   that is readable by a general or special purpose programmable computer for

18   configuring and operating the computer when the storage medium or device is

19   read by the computer to perform the procedures described in this document. The

20   system may also be considered to be implemented as a computer-readable storage

1   medium, configured with a computer program, where the storage medium so

2   configured causes a computer to operate in a specific and predefined manner.

3

4   Finally, an embodiment of the present invention having potential commercial

5   success is integrated in the Planetii™ Math System™, an online math education

6   software product, available at <http://www.planetii.com/home/>.

7

8   Figure 14 depicts an exemplary user interface depicting the various elements for

9   display. As shown, the question text data is presented as Display Area 2, the

10 potential answer choice(s) data is presented as Display Area 4, the correct answer

11 data is presented as Display Area 6, the Visual Aid data is presented as Display

12 Area 8 and the Descriptive Solution data is presented as Display Area 10.

13